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Some possibilities for reducing circular saw idling noise

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Abstract The sound pressure level of differently designed circular saw blades were investigated during idling. Nine blade samples were used: three differently designed blade bodies (without slots, with four radial slots, and with four slots with copper cork), each with three diameters (260, 280, and 300mm). The sound pressure level was measured at different rotational frequencies ranging from 25 to 65rps in increments of 1rps. Rubber damping rings 80mm in diameter and 0.3mm thick were placed between the saw blade and the collars, and the emitted noise was measured. Because of the whistling sound the blades without slots emitted high sound pressure levels. There were no significant changes when rubber damping rings were used. The use of rubber damping rings on the samples with radial slots eliminates the whistling noise. The saws with copper corks did not emit a whistling noise at all, and their aerodynamic noise was 2–3dB(A) lower than the aerodynamic noise of the saws with radial slots. The relation between sound pressure emitted by the damped idling saw and peripheral velocity can be described by the power function with the exponent value between 4.8 and 5.2.

Key words Idling circular saw · Whistling noise · Noise level · Rubber damping rings

Introduction

The noise emitted by circular saws usually increases with rotation frequency so at higher cutting speeds it becomes a true health risk. Circular saws often reach higher noise levels when idling than when sawing, which is why a strong resonant noise with discrete tones, known as the whistling noise, occurs at idling.[1–3] The idling time share in the total time is significantly higher than the sawing time share, especially when circular saws are used for crosscutting. It is therefore important to investigate and reduce the idling noise.

Leu and Mote[4] studied the idling noise of circular saws and concluded that whistling noise is the result of the interrelation between saw blade characteristics and airflow around the blade, so-called self-excited vibrations. The self-excited vibrations occur in circular saws with a low damping factor. Numerous research studies have shown that the whistling noise that occurs at idling can be suppressed by improving saw blade damping characteristics.[5–9]

The methods to improve the damping capacity of a saw blade can be classified into three groups[10]: (1) system damping (making comb-like slots over a saw body using a laser); (2) structural damping (making a saw blade with viscoelastic layers on a steel core or laminated saw blade); and (3) material damping (saw body made of a high-damping alloy). Hattori et al.[10] suggested material damping as an optimal solution to the problem of whistling noise. They even developed a special alloy for circular saw blades that has sufficient mechanical and damping characteristics.

To suppress the whistling noise, Kimura's group[11] suggested use of a circular saw with step thickness (thick at the inner part). At the same time, Yanagimoto et al.[12] tried to decrease the circular saw noise with a special tooth design. Research has shown that there are many possibilities for avoiding self-excited vibrations and for suppressing whistling noise using new designs and production technologies for circular saw blades, but all have some disadvantages.[10]

Marui et al.[13] investigated a thin plate structure as a model of a circular saw and the efficiency of various damping foils inserted between the collars and the saw blade model. Damping achieved by the saw blade clamping system can significantly reduce the noise level at idling. The cost of these clamping systems is fairly low, increasing interest in such research.

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Materials and methods

The research was carried out on samples of nine circular saw blades divided in three groups by their diameter. The characteristics of the samples of each group are given in Table 1. All the samples have 56 teeth of the same type. The blade thickness of all the samples was 2mm, with all having the same kerf width. Each group consisted of three differently designed saws: (1) without radial slots; (2) with four radial slots; and (3) with copper corks in the holes at the end of the radial slots. Figure 1 illustrates the different saw designs in a group with the same diameter.

The radial slots on the saws in sample "b" of the 260mm saw blade diameter are 22mm long (i.e., on saws of 280 and 300mm the saw blade diameters are 25mm). The saws in sample "c" have copper corks at the end of the slots; the core diameter is 10mm. The slots on the saw of the blades of diameters 260, 280, and 300mm were 22, 27, and 29mm, respectively.

The noise level measurements were carried out in accordance with ISO 1996, ISO 1999, and ISO 2204. The measuring chain is shown in Fig. 2. The microphone (type 4165; Brüel & Kjær) was placed 95cm from the ground. To obtain completely comparable results and to maintain the same level of the environmental noise, special care was taken that during all measurements the microphone remained in the same position for all samples. The soundmeter (type 2209; Brüel & Kjær) was set to frequency weighting "Lin." and time-weighting "F." The overall aerodynamic sound pressure level in decibels [dB(A)] was recorded by a real-time frequency analyzer at rotational frequencies ranging from 25 to 65rps in increments of 1rps (frequency converter Regatron regadrive, type FVR G5, was used). All measurements were carried out at idling. The noise level emitted by the circular saw damped by rubber rings inserted between the collars and the saw blade was measured as well. The rubber for the damping rings is made of a 60% solution of natural caoutchouc with ammonia water. The saw blades were clamped with 80mm diameter collars. The rubber damping rings were of the same diameter as the collars and were 0.3mm thick.

Table 1. Basic characteristics of saw blade samples

Properties	Group 1	Group 2	Group 3
Saw diameter (mm)	260	280	300
Pitch (mm)	15	16	17
Tooth height (mm)	10	10	11
Clearance angle (degrees)	24	21	21
Hook angle (degrees)	20	22	22

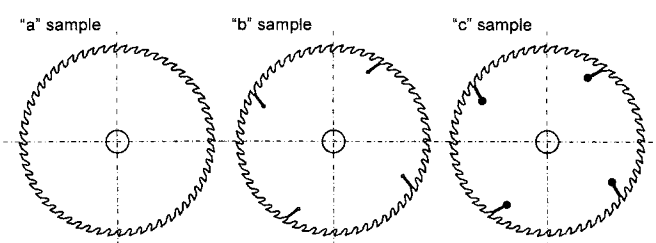

Fig. 1. Design of saw blades in each of the tested groups

Results and discussion

The relations between the noise level and the circular saw rotational frequency for tested saws are shown in Fig. 3. The noise emitted by circular saws without radial slots increases with the increase in rotational frequency [Fig. 3(1)], with peak values that clearly identify whistling noise caused by self-excited vibrations. The noise emitted by circular saws of 260mm o.d. without radial slots is higher than the noise emitted by the other two types of saw with the same outside diameter in almost the entire range of rotational frequencies. The difference between the levels of emitted noise amounted to as much as 15dB(A). In the other two groups (saws with saw blades having outside diameters of 280 and 300mm) the differences between the levels of noise emitted by saws with and without slots were lower. This can be probably explained by the larger gullet area in larger-diameter saws (all saws had the same number of teeth so the saws of larger diameter have a larger gullet area). It can be said that radial slots significantly reduce the noise emitted by circular saws of small diameter or small gullet area (or both). Similar results were obtained by Yokochi et al.,[14] who measured the noise level emitted by circular saws of the same outside diameter but with various numbers of teeth. Therefore, it is necessary to include radial slots on small-diameter saw blades or saw blades with a small gullet area (i.e., large number of teeth).

It is obvious that saws with radial slots rarely emit a whistling noise, whereas saws with slots emit a larger aerodynamic sound than do saws without slots, especially those with a large diameter and increased rotational frequency.

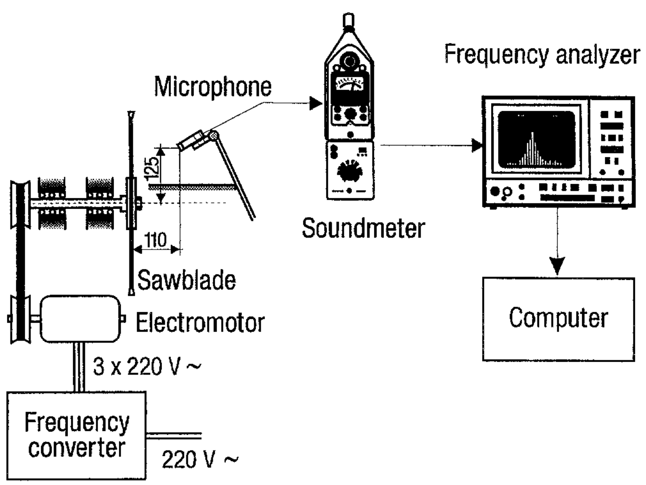

Fig. 2. Arrangment of instruments used for the experiment

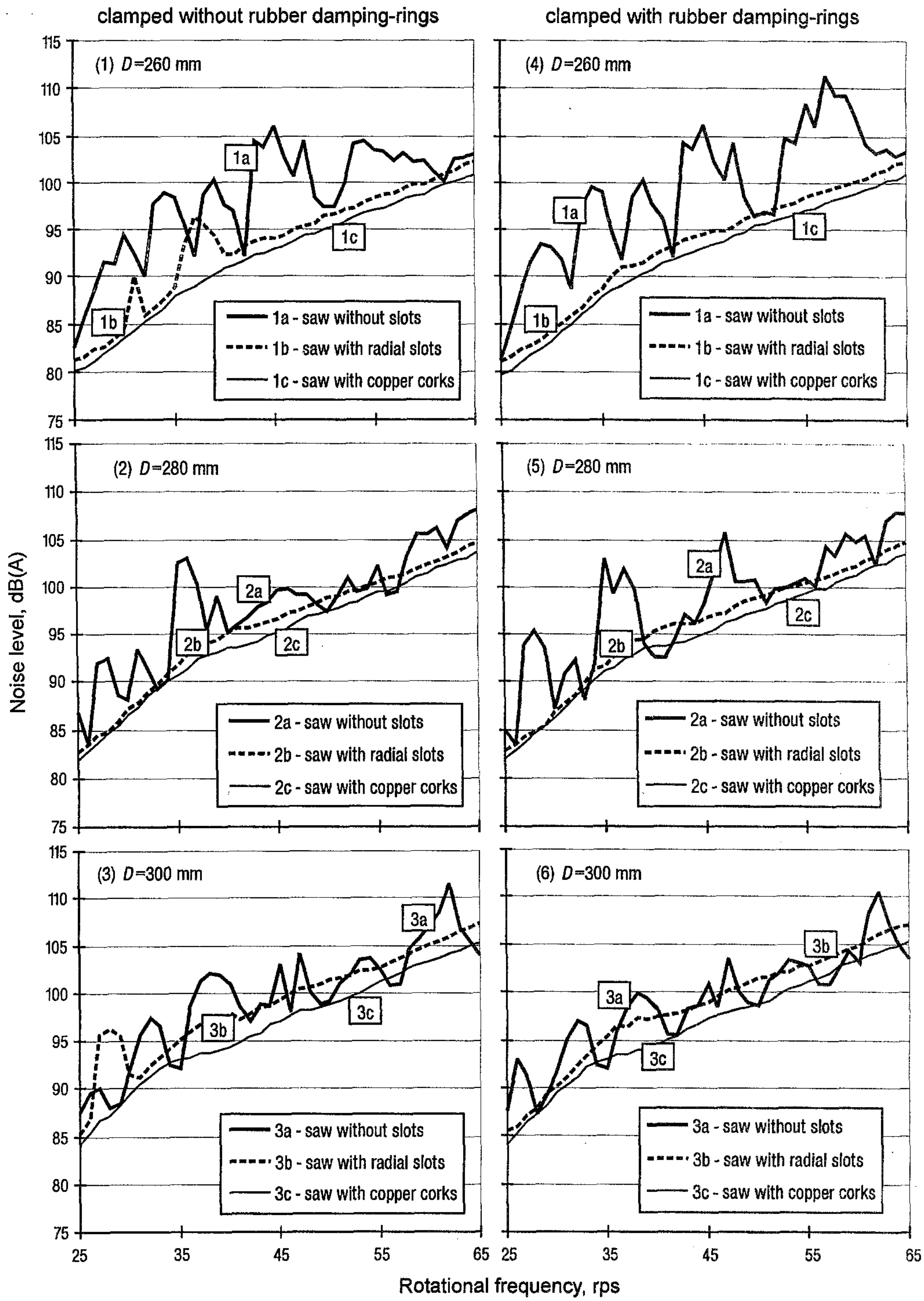

Fig. 3. Relation between the noise level emitted by various circular saws and the rotational frequency

The reason may be the aerodynamic sound that originates from holes at the end of the slots. From graphs (3) and (6) in Fig. 3 it is evident that the copper corks placed at the end of the slots comprise an effective method for eliminating the whistling noise of idling circular saws. At the same time, the aerodynamic sound level of the saws with copper corks is close to the aerodynamic sound level emitted by the circular saws without slots.

The results obtained for circular saws clamped with a rubber foil inserted between the saw blade and the collars are shown in Fig. 3, diagrams (4)–(6). A comparison of the results with and without damping rings shows that the use of rubber damping rings decreases only the noise level emitted by saws with radial slots. The relation between the noise level and rotational frequency for saw blades whose idling noise was significantly reduced by use of damping rings are shown in Fig. 4.

As is evident in Fig. 4, the rubber damping rings inserted between the collars and the saw blade eliminate the whistling noise completely. Circular saws with radial slots are used fairly frequently, so insertion of rubber damping rings between the saw blade and collars may be an

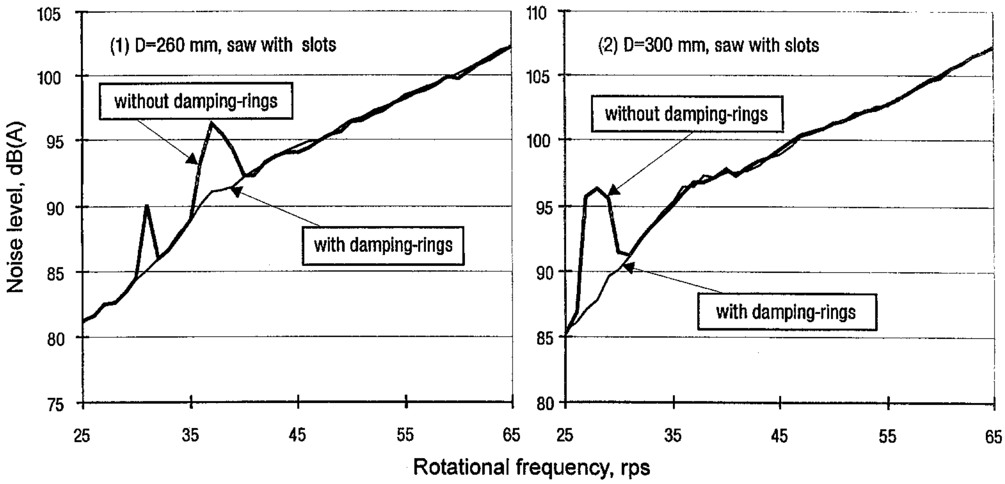

Fig. 4. Influence of the rubber damping rings on the whistling noise of circular saws with radial slots

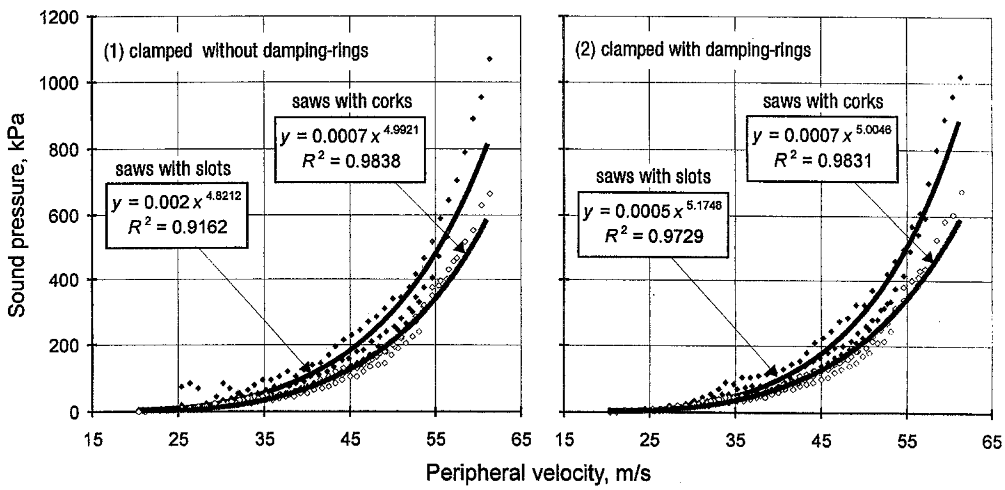

Fig. 5. Relation between the sound pressure emitted by the idling circular saw and the peripheral velocity

effective, inexpensive way to eliminate the whistling noise. This is important because some of the previously mentioned damping methods are much more expensive, although their effects are the same: elimination of whistling noise.

The noise level emitted by saws without radial slots (Fig. 3) cannot be expressed as dependent on the saw blade's outside diameter because they emit whistling noise. The levels of the noise emitted by saw blades with large diameters, saws with radial slots, and the saws with copper corks are considerably higher, indicating that the level of aerodynamic sound depends on the outside diameter. When the outside diameter is increased by 20mm, the noise level increases 2–3dB(A) over the whole range of rotational frequencies.

The sound pressures emitted by saw blades with radial slots and saw blades with copper corks in relation to the peripheral velocity are shown in Fig. 5. This relation can be described by a power function. Figure 5 illustrates the fitted equations as well. Correlation coefficients show a strong relation between the measured points and the fitted curve. Exponents in the fitted equations are between 4.8 and 5.2 and are comparable to results in literature.[1,2]

Conclusions

The whistling noise of the undamped saw blades increases the noise level 10–15dB(A). Saw blades without radial slots emit a high-level noise during idling caused by self-excited vibrations. For such saw blades the noise level cannot be changed by using rubber damping rings.

Whistling noise also occurs, but rarely, with saw blades having radial slots. By inserting rubber damping rings between the collars and the saw blade with radial slots, the whistling noise can be completely suppressed. In the rotational frequency range in which the saw blades were tested, the saw blades with copper corks at the end of radial slots produced no whistling noise at all. Over the whole range of rotational frequencies, the noise level was 2–3dB(A) lower than that of circular saws with radial slots. This difference can be explained by the aerodynamic sound that originates from the slots and holes at the end of the slots (because the slots are made by punching).

The insertion of rubber damping rings between the saw blade and collars in combination with a slotted circular saw may be an effective, inexpensive way to eliminate the whistling noise of idling circular saws.

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